RESEARCH DEPARTMENT

Effect of fabric coverings on the sound absorption of porous materials

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EFFECT OF FABRIC COVERINGS ON THE SOUND ABSORPTION OF POROUS MATERIALS

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SUMMARY

Measurements have been carried out by the reverberation room method to determine the effect of fabric coverings on the sound absorption of porous backing materials. It is hoped that it may prove possible in the future to predict the behaviour of materials from measurements on small samples.

1. INTRODUCTION

In recent years Tygan or perforated hardboard covers for absorbers have become unpopular with many of the users of studios and other types of fabric have been considered as possible substitutes for these materials. The Tygan coverings are manufactured from a plastic fibre and are generally of an open weave construction, making them effectively transparent to sound. Perforated and slotted hardboard covers are sometimes used to produce a resonance peak in the absorption characteristic or to reduce the absorption at high frequencies. Suitable combinations of absorbers with such coverings have been produced to give absorption characteristics of many desired forms.

Since it was not known how far these effects could be reproduced by other fabrics, measurements were undertaken to determine the absorption of resistive materials with fabrics draped or stretched over their surfaces. The two major factors in the construction of a fabric considered to be of importance are the surface density of the material and the flow resistance. The surface density of a material is defined as the mass per unit area of the material (gm/m^2) while the flow resistance is defined by the relationship

$$R = p/v$$

where R is the flow resistance (rayls)

p is a pressure differential maintained across the sample (dyne/cm^2)

v is the velocity of airflow through the sample produced by the pressure differential (cm/sec).

It was thought probable that the 'fluffiness' of the material would affect the high frequency absorption obtained with the sample, and though no simple method of measuring this was apparent, this factor was borne in mind in assessing the effects of surface density and flow resistance.

Measurements of weight and flow resistance were made on a large number of fabrics to determine the range of the parameters involved and six fabrics were selected for full-scale measurements of absorption coefficient in the reverberation room (Table 1). Sufficient fabric was purchased to enable 100 ft^2 (9·5 m^2) of porous material to have twice its own area of fabric draped in front of it.

TABLE 1

Flow Resistance and Weight of Chosen Fabrics

Fabric	Surface Density (gm/m^2)	Flow Resistance (rayls)
Cotil Fabrics Kval 1703	156	11
Cotil Fabrics Kval 5750	155	33
Cotton Everglaze	151	138
Spectrum Fabrics Range 191/A958	518	10·5
Edinburgh Weavers Tiana 0321	480	32
Sundour Fabrics	470	230

Measurements were carried out with the fabrics alone and covering two types of resistive backing material which were near the ends of the range of flow resistance found with such materials. They were Bondacoust wadding (of flow resistance about 5 rayls/cm) and Stillite Therbloc (of flow resistance about 110 rayls/cm).

The BBC's standard method of measurement of absorption in the reverberation room was followed. Four frames, each of area 6 ft × 4 ft (1·8 m × 1·2 m) were mounted on the walls and floor of the large reverberation room, measurements were made of the reverberation time with and without the sample, and the absorption was calculated from the change of the average reverberation time.

2. RESULTS

The range of values of surface density and flow resistance which were obtained with a large number of samples is shown in Fig. 1; the results for the six materials chosen for full-scale tests are ringed in this figure. The selection was made to allow the influence of flow resistance variation to be studied at each of two

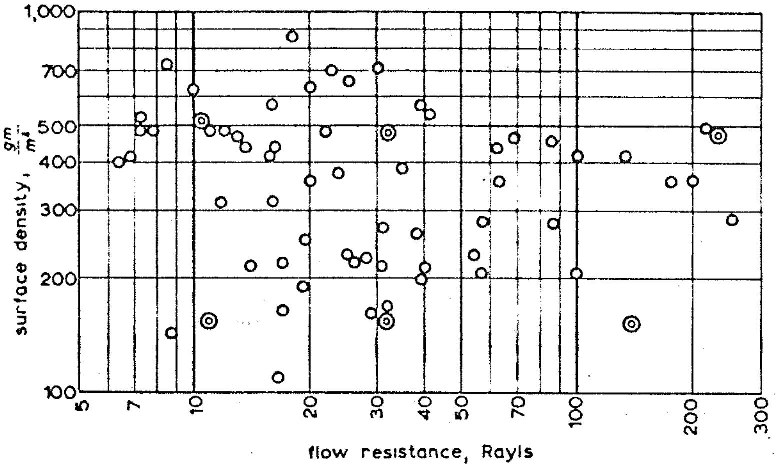


Fig. 1 - Values of flow resistance and surface density of fabrics

○ Fabrics used for preliminary measurements

◎ Fabrics selected for reverberation room measurements

surface densities of materials. No selection of surface finish was possible and the heavy fabrics are all more fluffy than the light ones. The values of flow resistance and surface density encompass a wide variety of materials and may enable prediction of behaviour of further materials to be made by interpolation.

2.1. Absorption Coefficients with Stretched Fabrics

Figs. 2 and 3 show the absorption coefficients obtained with the six selected fabrics stretched over a 2 inch (5 cm) layer of Bondacoust. Figs. 4 and 5 are the results for the fabrics stretched over a 2 inch (5 cm) layer of Therbloc. It can be seen from these results that a wide range of absorption characteristics may be obtained, and certain trends emerge.

Compared with the absorption of an uncovered low-resistance backing material such as Bondacoust, all the covering materials produce an increase in absorption at frequencies below about 700 c/s, accompanied by a reduction of absorption at the higher frequencies. These trends become more evident as the flow resistance of the fabric is increased, but for the heavy fabrics which all have 'fluffy' surfaces the high frequency absorption is largely recovered. The variation of absorption with surface density at a given flow resistance is masked at high frequencies by the surface absorption of the heavy materials but it does appear that at the low frequencies the heavier material absorbs more efficiently.

Compared with the absorption of an uncovered high resistance backing material such as Therbloc, only slight increases of absorption are found at the lower frequencies, and the characteristic high frequency reductions are not so severe as with Bondacoust. It appears that the high flow resistance of the backing material is sufficient to swamp some of the effects of the flow resistance of the fabrics.

The lightweight fabrics give rise to a greater total absorption when measured with a high resistance backing than with a low resistance backing. The peak value of absorption which is at or about 500 c/s is practically the same for both backings but elsewhere an increase of absorption is found. With the heavy fabrics the backing does not greatly affect the absorption at medium and high frequencies but at the lower frequencies an improvement is found when using the high resistance backing for all except the high flow resistance fabric.

Influence of flow resistance on the absorption of fabrics stretched over 2 inch (5 cm) Bondacoust

Fig. 2 - Lightweight fabrics

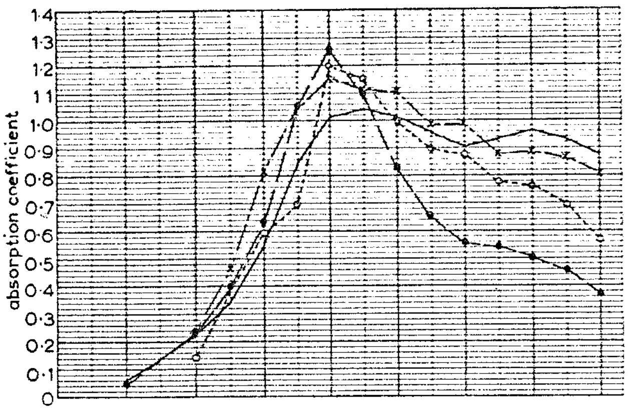
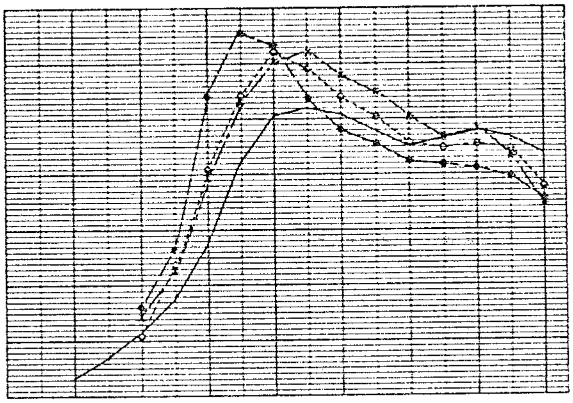


Fig. 3 - Heavy fabrics



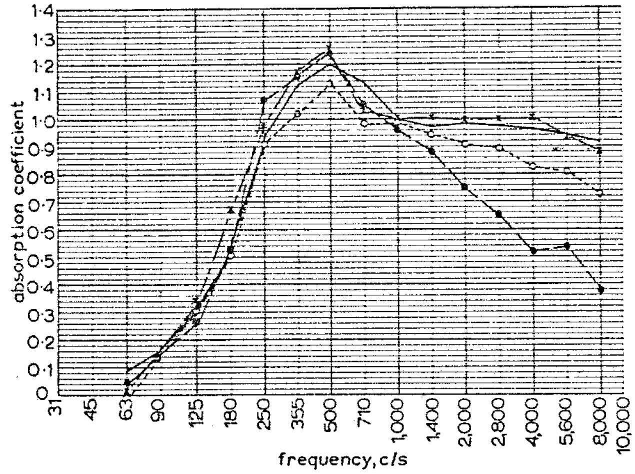


Fig. 4 - Lightweight fabrics

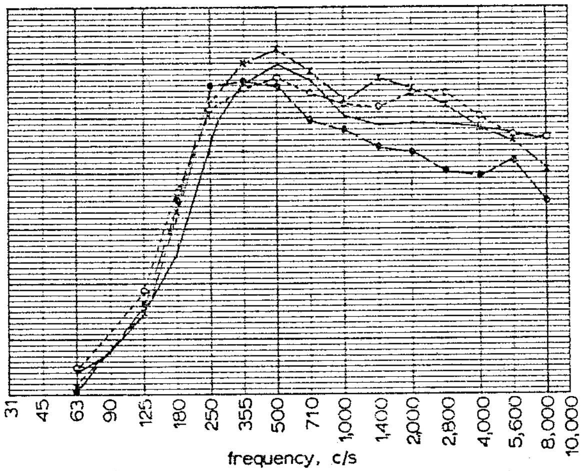


Fig. 5 - Heavy fabrics

Influence of flow resistance on the absorption of fabrics stretched over 2 inch (5 cm) Therbloc

—x— low flow resistance
---o--- medium flow resistance
—●— high flow resistance
——— no fabric

2.2. Absorption Coefficients with Draped Fabrics

Since it is frequently preferred, for aesthetic reasons, to use fabrics draped rather than stretched over a surface, the measurements were carried out for each fabric over each backing with twice the area of fabric hung in folds over the original sample area.

Figs. 6 and 7 show a comparison of the results obtained in two extreme cases with fabrics draped or stretched. It is not necessary to reproduce all the results obtained but the following tendencies were found:

(a) With low flow resistance fabrics, stretching is more effective than draping when a low resistance backing is used, and it still remains almost as effective with a high resistance backing.

(b) With medium flow resistance fabrics stretching is as effective as draping when a low resistance backing is employed but less effective with a high resistance backing.

(c) With high flow resistance fabrics draping is always more effective than stretching.

2.3. Absorption Coefficients of Fabrics with No Porous Backing Material

Measurements were made with the fabrics stretched or draped in front of a 2 inch (5 cm) air space with no porous backing material. Figs. 8 and 10 show the absorption characteristics of stretched heavy and light fabrics respectively.

In the case of heavy fabrics an increase of flow resistance leads to improved absorption at the lower frequencies coupled with a slight increase of the peak values. Two of the lightweight fabrics show the same effect but the third, a high flow resistance fabric, upsets the pattern; this may be due to a membrane resonance of the fabric. This resonance effect has been found also in impedance tube measurements, the frequency of resonance being proportional to the square root of the tension with which the fabric was stretched across the tube.

Comparison of the effects of draping or stretching a fabric over a resistive backing material

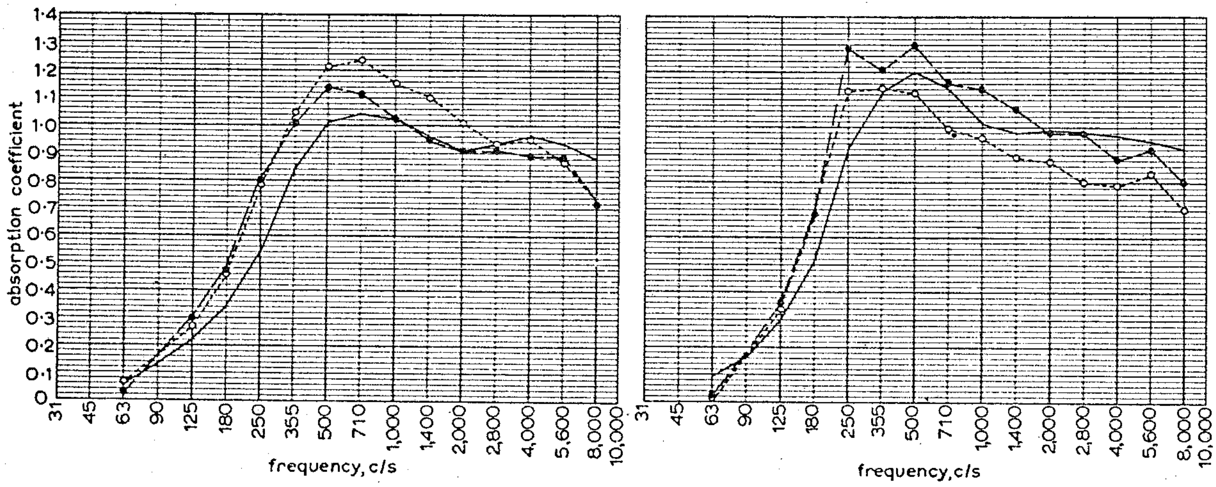


Fig. 6 - Low flow resistance fabric

Fig. 7 - High flow resistance fabric

---o--- draped fabric

——●—— stretched fabric

———— no fabric

Influence of flow resistance on the absorption of heavy fabrics over a 2 inch (5 cm) air space

Fig. 8 - Fabrics stretched

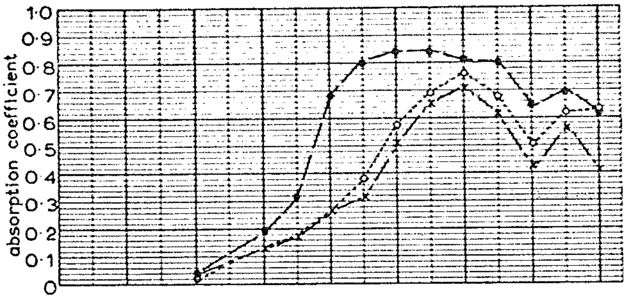
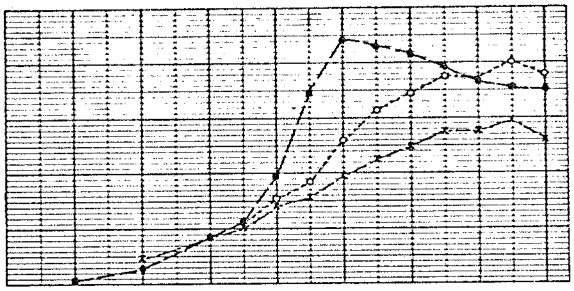


Fig. 9 - Fabrics draped



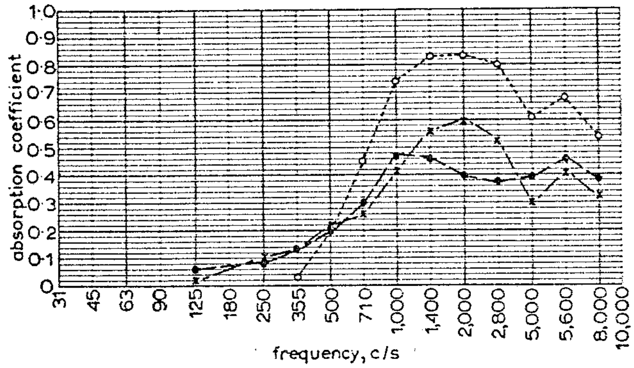


Fig. 10 - Fabrics stretched

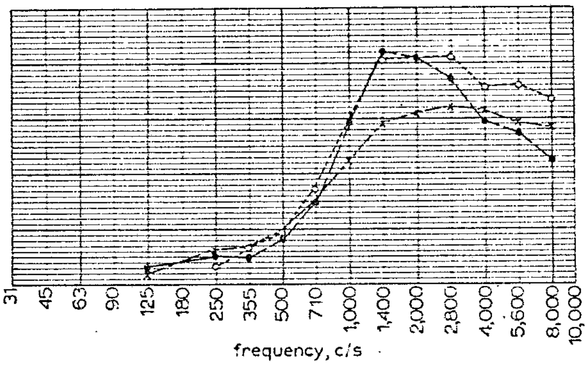


Fig. 11 - Fabrics draped

Influence of flow resistance on the absorption of lightweight fabrics over a 2 inch (5 cm) air space

--•-- high flow resistance ----o--- medium flow resistance
—-x-— low flow resistance

Draping of heavy fabrics is generally not advantageous and, in fact, some loss of low frequency absorption is found (compare Figs. 8 and 9). With the lightweight fabrics, however, a general improvement is found at high frequencies, particularly in the case of the high flow resistance fabric (Figs. 10 and 11).

3. PREDICTION OF BEHAVIOUR OF FURTHER MATERIALS

It was expected at the outset of these measurements that an estimate of the behaviour of additional materials could be made by interpolation or limited extrapolation from the measured results. A determination of the surface density and flow resistance coupled with the feel of the surface should enable a reasonable estimate of the absorption to be made.

One occasion has in fact arisen in which verification of an estimate was possible. A lightweight Duracour of flow resistance 170 rayls and surface density 160 gm/m^2 would be expected to behave in the same way as the Cotton Everglaze measured previously. A comparison of the results is shown in Figs. 12 and 13. The general trend is similar but lower values are found at 500 c/s for the Duracour than for the Cotton Everglaze.

Comparison of absorption coefficients obtained with lightweight Duracour and Cotton Everglaze over two resistive backing materials

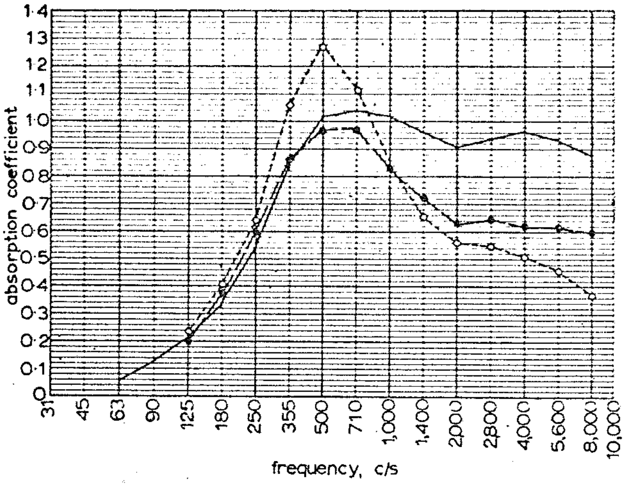


Fig. 12 - Bondacoust backing

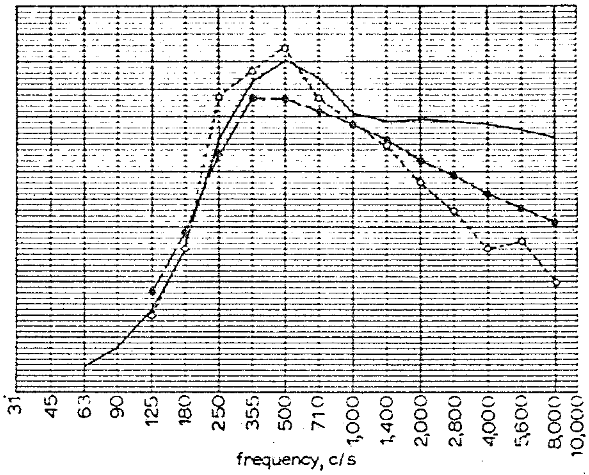


Fig. 13 - Therbloc backing

---o--- Cotton Everglaze

---•--- lightweight Duracour

——— no fabric

More recently it has been shown that it is possible to calculate the absorption at random incidence for a finite sample area[1] from tube admittance measurements. Such measurements[2] are made on a small piece of the material which is mounted at one end of a cylindrical tube. A loudspeaker at the other end generates plane sound waves in the tube and a probe microphone explores the standing wave pattern which is set up. From a determination of the position and depth of the interference minima it is possible to calculate the acoustic impedance or admittance of the sample.

The calculation based on Northwood's results is shown in Figs. 14, 15, 16 and 17 to be capable of a good approximation to the measured values for both low and high resistance backing materials. However, in the case of the lightweight high flow resistance fabrics resonance effects occur as mentioned previously. Two calculated curves are shown in Fig. 16 for this case and the difference between these two sets of results is representative of the uncertainty that might exist in figures derived from measurements on small samples.

4. DISCUSSION AND CONCLUSIONS

The measurements described have confirmed that a wide range of absorption characteristics may be obtained with different fabric coverings. If the maximum absorption over the widest frequency range is required, materials of high surface density and low flow resistance should be used over a high resistance backing. It is also possible to obtain an absorption characteristic similar to that obtained from perforated materials; many of the lower or medium flow resistance materials have absorption characteristics very similar to those observed with 25% perforated hardboard. The lightweight high flow resistance materials have properties very similar to those observed for 5% perforated hardboard.

Comparison of measured and calculated absorption coefficients of fabrics stretched over 2 inch (5 cm) Bondacoust

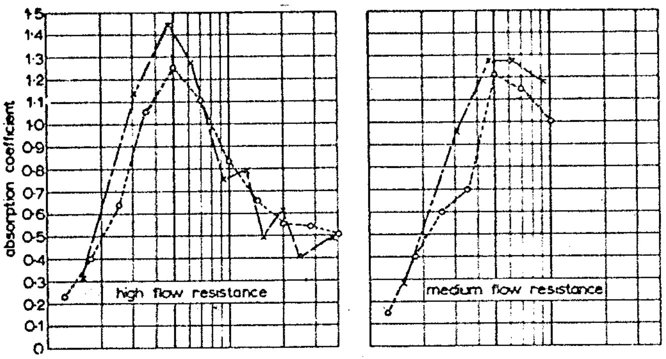


Fig. 14 - Lightweight fabrics

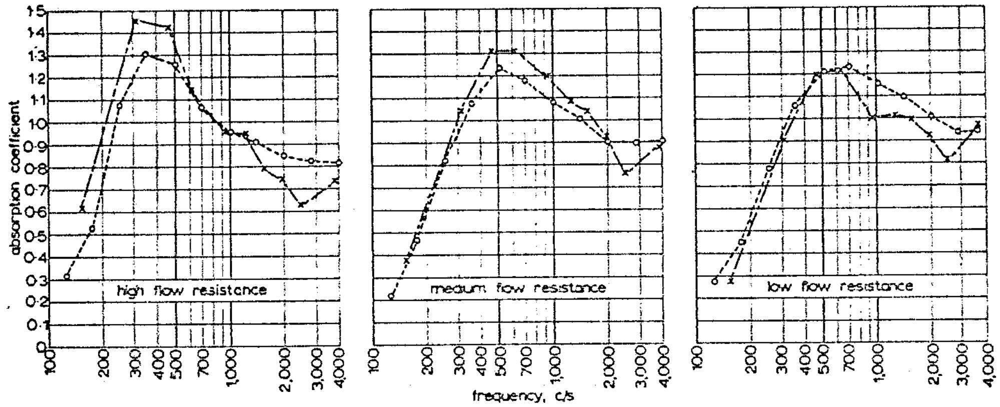


Fig. 15
Heavy fabrics

Comparison of measured and calculated absorption coefficients of fabrics stretched over 2 inch (5 cm) Therbloc

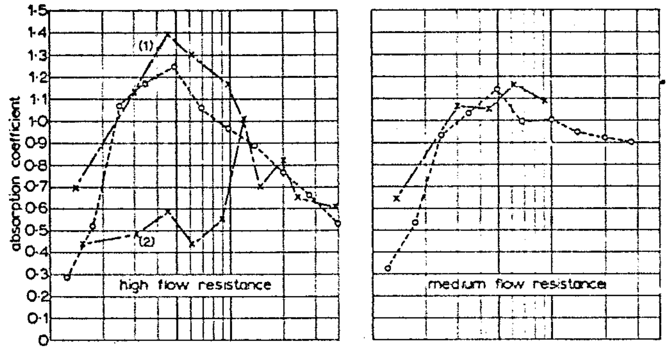


Fig. 16 - Lightweight fabrics

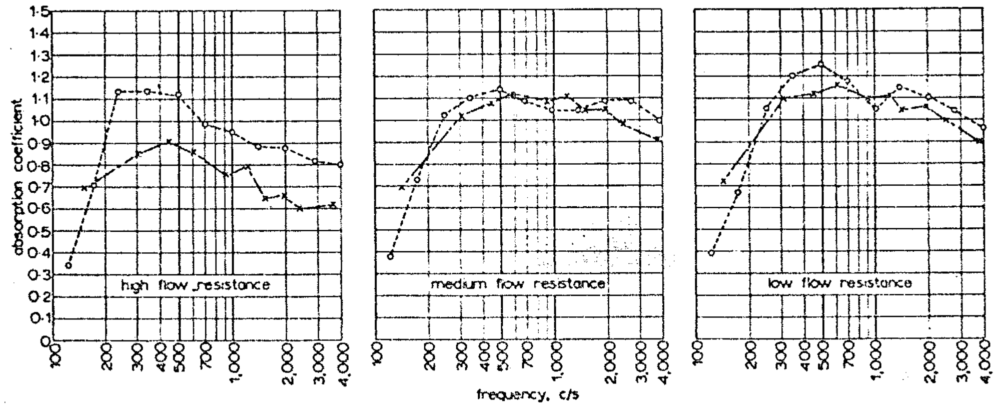


Fig. 17
Heavy fabrics

——x—— calculated ------o------ measured

Some of the synthetic washable materials considered since these measurements were made have been found to exhibit very wide variations of flow resistance from sample to sample and in these cases a system of test measurements on each batch has had to be instituted. For conventional fabrics, of more consistent construction, an estimate of the behaviour of a specific type should be possible on the basis of the measurement of their surface density and flow resistance. Confirmation of these estimates can be obtained from impedance tube measurements in cases where the detailed mounting of the fabric is not a major factor in its behaviour.

5. REFERENCES

1. Northwood, Grisaru and Medcof, 'Absorption of Sound by a Strip of Absorptive material in a Diffuse Sound Field', J.A.S.A. 1959*, Vol. 31, No. 5, pp. 595 - 599.*

2. See, for example, Beranek, L., 'Acoustic Measurements', (John Wiley & Sons, Inc.), 1950, pp. 317 - 336.

*The results contained in this paper have been greatly extended in range in an unpublished paper recently obtained privately from Dr. Northwood.

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